

APPENDIX A

LOADING - H 15-44 (M13.5)

**TABLE OF MAXIMUM MOMENTS, SHEARS AND REACTIONS.
SIMPLE SPANS, ONE LANE**

Spans in feet; moments in thousands of foot-pounds; shears and reactions in thousands of pounds. These values are subject to specification reduction for loading of multiple lanes. Impact not included.

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
1	6.0(b)	24.0(b)	26	156.0(b)	26.8(b)
2	12.0(b)	24.0(b)	27	162.7(b)	26.9(b)
3	18.0(b)	24.0(b)	28	170.1(b)	27.0(b)
4	24.0(b)	24.0(b)	29	177.5(b)	27.1(b)
5	30.0(b)	24.0(b)	30	185.0(b)	27.2(b)
6	36.0(b)	24.0(b)	31	192.4(b)	27.3(b)
7	42.0(b)	24.0(b)	32	199.8(b)	27.4(b)
8	48.0(b)	24.0(b)	33	207.3(b)	27.5(b)
9	54.0(b)	24.0(b)	34	214.7(b)	27.7
10	60.0(b)	24.0(b)	35	222.2(b)*	27.9
11	66.0(b)	24.0(b)	36	229.6(b)	28.1
12	72.0(b)	24.0(b)	37	237.1(b)	28.4
13	78.0(b)	24.0(b)	38	244.5(b)	28.6
14	84.0(b)	24.0(b)	39	252.0(b)	28.9
15	90.0(b)	24.0(b)	40	259.5(b)	29.1
16	96.0(b)	24.8(b)	42	274.4(b)	29.6
17	102.0(b)	25.1(b)	44	289.3(b)	30.1
18	108.0(b)	25.3(b)	46	304.3(b)	30.5
19	114.0(b)	25.6(b)	48	319.2(b)	31.0
20	120.0(b)	25.8(b)	50	334.2(b)	31.5
21	126.0(b)	26.0(b)	52	349.1(b)	32.0
22	132.0(b)	26.2(b)	54	364.1(b)	32.5
23	138.0(b)	26.3(b)	56	379.1(b)	32.9
24	144.7(b)	26.5(b)	58	397.6	33.4
25	150.4(b)	26.6(b)	60	418.5	33.9

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.



LOADING - H 15-44 (M13.5)

(Continued)

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
62	439.9(b)	34.4	150	1856.3(b)	55.5
64	461.8(b)	34.9	160	2076.0(b)	57.9
66	484.1(b)	35.3	170	2307.8(b)	60.3
68	506.9(b)	35.8	180	2551.5(b)	62.7
70	530.3(b)	36.3	190	2807.3(b)	65.1
75	590.6(b)	37.5	200	3075.0(b)	67.5
80	654.0(b)	38.7	220	3646.5(b)	72.3
85	720.4(b)	39.9	240	4266.0(b)	77.1
90	789.8(b)	41.1	260	4933.5(b)	81.9
95	862.1(b)	42.3	280	5649.0(b)	86.7
100	937.5(b)	43.5	300	6412.5(b)	91.5
110	1097.3(b)	45.9			
120	1269.0(b)	48.3			
130	1452.8(b)	50.7			
140	1648.5(b)	53.1			

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

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**TABLE OF MAXIMUM MOMENTS, SHEARS AND REACTIONS.
SIMPLE SPANS, ONE LANE**

Spans in feet; moments in thousands of foot-pounds; shears and reactions in thousands of pounds. These values are subject to specification reduction for loading of multiple lanes. Impact not included.

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
1	6.0(b)	24.0(b)	31	223.0(b)	37.7(b)
2	12.0(b)	24.0(b)	32	234.4(b)	38.3(b)
3	18.0(b)	24.0(b)	33	245.8(b)	38.7(b)
4	24.0(b)	24.0(b)	34	257.7(b)	39.2(b)
5	30.0(b)	24.0(b)	35	270.9(b)	39.6(b)
6	36.0(b)	24.0(b)	36	284.2(b)	40.0(b)
7	42.0(b)	24.0(b)	37	297.5(b)	40.4(b)
8	48.0(b)	24.0(b)	38	310.7(b)	40.7(b)
9	54.0(b)	24.0(b)	39	324.0(b)	41.1(b)
10	60.0(b)	24.0(b)	40	337.4(b)	41.4(b)
11	66.0(b)	24.0(b)	42	364.0(b)	42.0(b)
12	72.0(b)	24.0(b)	44	390.7(b)	42.5(b)
13	78.0(b)	24.0(b)	46	417.4(b)	43.0(b)
14	84.0(b)	24.0(b)	48	444.1(b)	43.5(b)
15	90.0(b)	25.6(b)	50	470.9(b)	43.9(b)
16	96.0(b)	27.0(b)	52	497.7(b)	44.3(b)
17	102.0(b)	28.2(b)	54	524.5(b)	44.7(b)
18	108.0(b)	29.3(b)	56	551.3(b)	45.0(b)
19	114.0(b)	30.3(b)	58	578.1(b)	45.3(b)
20	120.0(b)	31.2(b)	60	604.9(b)	45.6(b)
21	126.0(b)	32.0(b)	62	631.8(b)	45.9(b)
22	132.0(b)	32.7(b)	64	658.6(b)	46.1(b)
23	138.0(b)	33.4(b)	66	685.5(b)	46.4(b)
24	144.5(b)	34.0(b)	68	712.3(b)	46.6(b)
25	155.5(b)	34.6(b)	70	739.2(b)	46.8(b)
26	166.6(b)	35.1(b)	75	806.3(b)	47.3(b)
27	177.8(b)	35.6(b)	80	873.7(b)	47.7(b)
28	189.0(b)	36.0(b)	85	941.0(b)	48.1(b)
29	200.3(b)	36.6(b)	90	1008.3(b)	48.4(b)
30	211.6(b)	37.2(b)	95	1074.9(b)	48.7(b)

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

**LOADING - H 15-44 (M13.5)**
(Continued)

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
100	1143.0(b)	43.5(b)	200	3075.0	67.5
110	1277.7(b)	45.9(b)	220	3646.5	72.3
120	1412.5(b)	48.3(b)	240	4266.0	77.1
130	1547.3(b)	50.7	260	4933.5	81.9
140	1682.1(b)	53.1	280	5649.0	86.7
150	1856.3	55.5	300	6412.5	91.5
160	2076.0	57.9			
170	2307.8	60.3			
180	2551.5	62.7			
190	2807.3	65.1			

- (a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.
(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.



LOADING - H 20-44 (M18)

TABLE OF MAXIMUM MOMENTS, SHEARS AND REACTIONS.
SIMPLE SPANS, ONE LANE

Spans in feet; moments in thousands of foot-pounds; shears and reactions in thousands of pounds. These values are subject to specification reduction for loading of multiple lanes. Impact not included.

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
1	8.0(b)	32.0(b)	31	256.5(b)	36.4(b)
2	16.0(b)	32.0(b)	32	266.5(b)	36.5(b)
3	24.0(b)	32.0(b)	33	276.4(b)	36.6(b)
4	32.0(b)	32.0(b)	34	286.3(b)	36.9
5	40.0(b)	32.0(b)	35	296.2(b)	37.2
6	48.0(b)	32.0(b)	36	306.2(b)	37.5
7	56.0(b)	32.0(b)	37	316.1(b)	37.8
8	64.0(b)	32.0(b)	38	326.1(b)	38.2
9	72.0(b)	32.0(b)	39	336.0(b)	38.5
10	80.0(b)	32.0(b)	40	346.0(b)	38.8
11	88.0(b)	32.0(b)	42	365.9(b)	39.4
12	96.0(b)	32.0(b)	44	385.8(b)	40.1
13	104.0(b)	32.0(b)	46	405.7(b)	40.7
14	112.0(b)	32.0(b)	48	425.6(b)	41.4
15	120.0(b)	32.5(b)	50	445.6(b)	42.0
16	128.0(b)	33.0(b)	52	465.5(b)	42.6
17	136.0(b)	33.4(b)	54	485.5(b)	43.3
18	144.0(b)	33.8(b)	56	505.4(b)	43.9
19	152.0(b)	34.1(b)	58	530.1	44.6
20	160.0(b)	34.4(b)	60	558.0	45.2
21	168.0(b)	34.7(b)	62	586.5	45.8
22	176.0(b)	34.9(b)	64	615.7	46.5
23	184.0(b)	35.1(b)	66	645.5	47.1
24	192.0(b)	35.3(b)	68	675.9	47.8
25	200.0(b)	35.5(b)	70	707.0	48.4
26	208.0(b)	35.7(b)	75	787.5	50.0
27	216.9(b)	35.9(b)	80	872.0	51.6
28	226.8(b)	36.0(b)	85	960.5	53.2
29	236.7(b)	36.1(b)	90	1053.0	54.8
30	246.6(b)	36.3(b)	95	1149.5	56.4

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

LOADING - H 20-44 (M18)

(Continued)

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
100	1250.0	58.0	200	4100.0	90.0
110	1463.0	61.2	220	4862.0	96.4
120	1692.0	64.4	240	5688.0	102.8
130	1937.0	67.6	260	6578.0	109.2
140	2198.0	70.8	280	7532.0	115.6
150	2475.0	74.0	300	8550.0	122.0
160	2768.0	77.2			
170	3077.0	80.4			
180	3402.0	83.6			
190	3743.0	86.8			

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

LOADING - H 20-44 (M18)
**TABLE OF MAXIMUM MOMENTS, SHEARS AND REACTIONS.
SIMPLE SPANS, ONE LANE**

Spans in feet; moments in thousands of foot-pounds; shears and reactions in thousands of pounds. These values are subject to specification reduction for loading of multiple lanes. Impact not included.

Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
1	8.0(b)	32.0(b)	31	297.3(b)	50.3(b)
2	16.0(b)	32.0(b)	32	312.5(b)	51.0(b)
3	24.0(b)	32.0(b)	33	327.8(b)	51.6(b)
4	32.0(b)	32.0(b)	34	343.5(b)	52.2(b)
5	40.0(b)	32.0(b)	35	361.2(b)	52.8(b)
6	48.0(b)	32.0(b)	36	378.9(b)	53.3(b)
7	56.0(b)	32.0(b)	37	396.6(b)	53.8(b)
8	64.0(b)	32.0(b)	38	414.3(b)	54.3(b)
9	72.0(b)	32.0(b)	39	432.1(b)	54.8(b)
10	80.0(b)	32.0(b)	40	449.8(b)	55.2(b)
11	88.0(b)	32.0(b)	42	485.3(b)	56.0(b)
12	96.0(b)	32.0(b)	44	520.9(b)	56.7(b)
13	104.0(b)	32.0(b)	46	556.5(b)	57.3(b)
14	112.0(b)	32.0(b)	48	592.1(b)	58.0(b)
15	120.0(b)	34.1(b)	50	627.9(b)	58.5(b)
16	128.0(b)	36.0(b)	52	663.6(b)	59.1(b)
17	136.0(b)	37.7(b)	54	699.3(b)	59.6(b)
18	144.0(b)	39.1(b)	56	735.1(b)	60.0(b)
19	152.0(b)	40.4(b)	58	770.8(b)	60.4(b)
20	160.0(b)	41.6(b)	60	806.5(b)	60.8(b)
21	168.0(b)	42.7(b)	62	842.4(b)	61.2(b)
22	176.0(b)	43.6(b)	64	878.1(b)	61.5(b)
23	184.0(b)	44.5(b)	66	914.0(b)	61.9(b)
24	192.7(b)	45.3(b)	68	949.7(b)	62.1(b)
25	207.4(b)	46.1(b)	70	985.6(b)	62.4(b)
26	222.2(b)	46.8(b)	75	1075.1(b)	63.1(b)
27	237.0(b)	47.4(b)	80	1164.9(b)	63.6(b)
28	252.0(b)	48.0(b)	85	1254.7(b)	64.1(b)
29	267.0(b)	48.8(b)	90	1344.4(b)	64.5(b)
30	282.1(b)	49.6(b)	95	1434.1(b)	64.9(b)

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

**LOADING - H 20-44 (M18)**

(Continued)

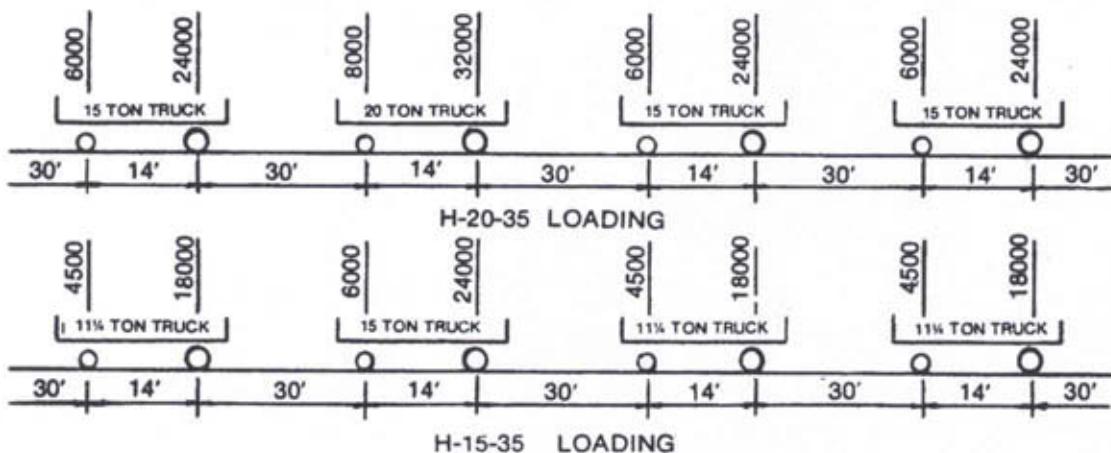
Span	Moment	End shear and end reaction (a)	Span	Moment	End shear and end reaction (a)
100	1524.0(b)	58.0(b)	200	4100.0	90.0
110	1703.6(b)	61.2(b)	220	4862.0	96.4
120	1883.3(b)	64.4(b)	240	5688.0	102.8
130	2063.1(b)	67.6	260	6578.0	109.2
140	2242.8(b)	70.8	280	7532.0	115.6
150	2475.1	74.0	300	8550.0	122.0
160	2768.0	77.2			
170	3077.1	80.4			
180	3402.1	83.6			
190	3743.1	86.8			

(a) Concentrated load is considered placed at the support. Loads used are those stipulated for shear.

(b) Maximum value determined by Standard Truck Loading. Otherwise the Standard Lane Loading governs.

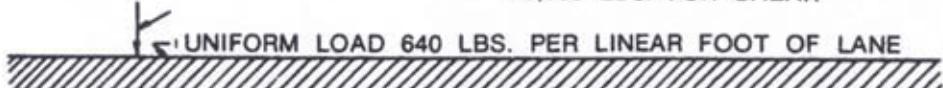
APPENDIX B

TRUCK TRAIN AND EQUIVALENT LOADINGS — 1935 SPECIFICATIONS AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS



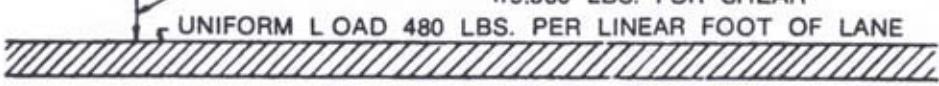
TRUCK TRAIN LOADING

CONCENTRATED LOAD — 18,000 LBS. FOR MOMENT
26,000 LBS. FOR SHEAR



H-20-35 LOADING

CONCENTRATED LOAD — 13,500 LBS. FOR MOMENT
19,500 LBS. FOR SHEAR

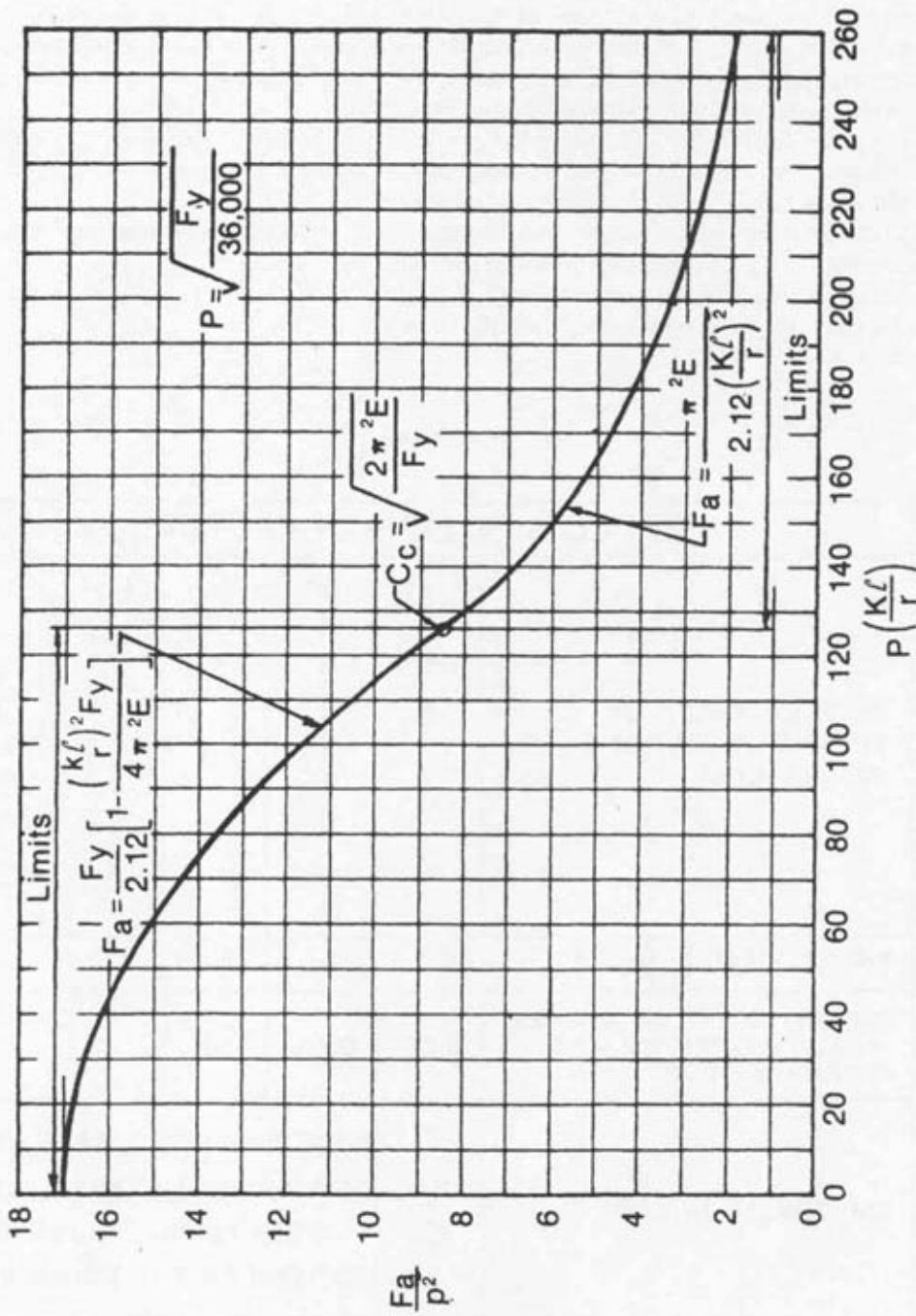


H-15-35 LOADING.

EQUIVALENT LOADING
LANE WIDTH 10 FEET

APPENDIX C

**FORMULA FOR COMPRESSION IN
CONCENTRICALLY LOADED COLUMNS**
(See Table 10.32.1A for Specific Values)



EFFECTIVE LENGTH FACTOR, K

The effective length of a compression member, KL , has been used to determine design strength of a compression member. K is a factor that when multiplied by the actual length of the end-restrained compression member, gives the length of an equivalent pin-ended compression member whose buckling load is the same as that of the end-restrained member. KL represents the length between inflection points of a buckled compression member. Restraint against rotation and translation of compression member ends influences the position of the inflection points. Theoretical values of K for some idealized compression member end conditions are given in Table C-1. Since compression member end conditions seldom comply fully with idealized conditions used in buckling analysis, the recommended values suggested by the Structural Stability Research Council are higher than the idealized values.

In trusses and frames where lateral stability is provided by diagonal bracing, shear walls, or other suitable means, the effective length factor, K , for compression members shall be taken as unity, unless structural analysis shows a smaller value may be used.

In the absence of a more refined analysis, the effective length factor K for the compression members in the braced plane in triangulated trusses, trusses, and frames may be taken as:

- For members riveted, or bolted or welded end conditions at both ends, $K = 0.75$

- For pinned connections at both ends: $K = 0.875$

Vierendell trusses shall be treated as unbraced frames

TABLE C-1

EFFECTIVE LENGTH FACTORS, K						
	(a)	(b)	(c)	(d)	(e)	(f)
BUCKLED SHAPE OF COLUMN IS SHOWN BY DASHED LINE						
THEORETICAL K VALUE	0.5	0.7	1.0	1.0	2.0	2.0
DESIGN VALUE OF K WHEN IDEAL CONDITIONS ARE APPROXIMATED	0.65	0.80	1.2	1.0	2.1	2.0
END CONDITION CODE					ROTATION FIXED TRANSLATION FIXED	
					ROTATION FREE TRANSLATION FIXED	
					ROTATION FIXED TRANSLATION FREE	
					ROTATION FREE TRANSLATION FREE	

- + In frames where lateral stability depends on the bending stiffness of the rigidly connected beams or columns, the effective length factor, K , for compression members shall be determined by structural analysis. The effective length factor, K , is dependent on the amount of stiffness supplied by the beams at the compression member ends. If the amount of stiffness supplied by the beams is small, the value of K could exceed 2.0.
- + In the absence of a more refined analysis, the following formulas and charts may be used to determine the effective length factor K for compression members in braced frames.
- + It is assumed that when elastic action occurs and all compression members buckle simultaneously in a frame, it can be rationally shown that

$$\frac{G_a G_b (\pi/K)^2 - 36}{6(G_a + G_b)} = \frac{\pi/K}{\tan(\pi/K)} \quad (C-1)$$

where subscripts a and b refer to the two ends of the compression member under consideration.

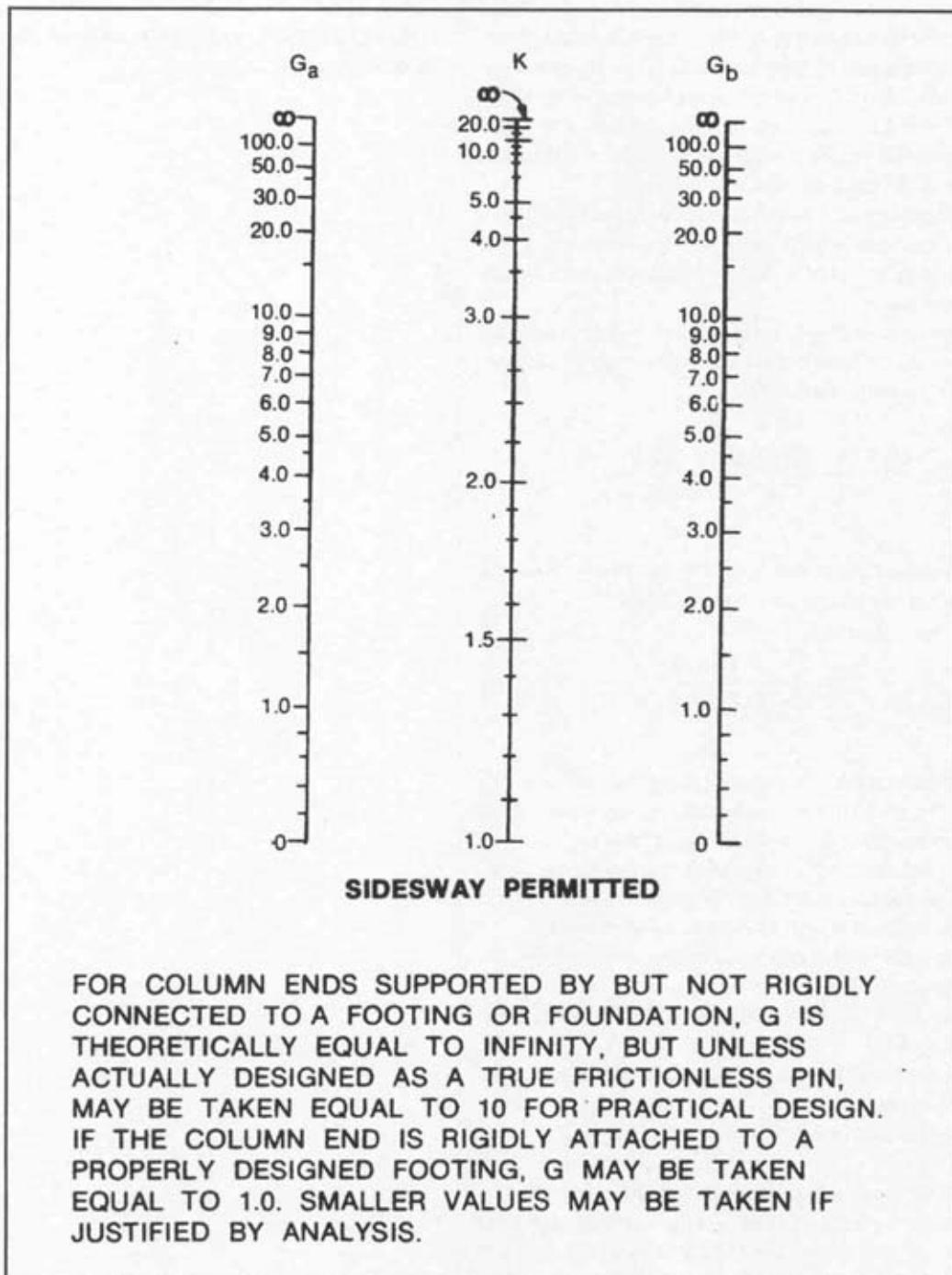
$$G = \frac{\sum(E_c I_c / L_c)}{\sum(E_g I_g / L_g)} \quad (C-2)$$

- Σ = summation of all members rigidly connected to the end of the compression member under consideration in the plane of bending
- E_c = modulus of elasticity of compression member
- I_c = moment of inertia of compression member
- L_c = unbraced length of compression member
- E_g = modulus of elasticity of beam or other restraining member
- I_g = moment of inertia of beam or other restraining member
- L_g = unbraced length of beam or other restraining member
- K = effective length factor

- Table C-2 is a graphical representation between K , G_a , and G_b , and can be used to obtain the value of K easily.
- + Equation C-1 and the alignment chart in Table C-2 are based on the assumptions of idealized conditions. The development of the chart and formulas can be found in textbooks such as Salmon and Johnson (1996) and Chen and Lui (1991). When actual structural conditions differ from these assumptions, unrealistic design may result.
 - + The modification procedures proposed by Galambos

(1988), Yura (1971), Disque (1973), Duan and Chen (1989, 1996), Essa (1997), LeMessurier (1977) and AISC-LRFD (1993) may be used to evaluate K-factors more accurately.

TABLE C-2



In computing effective length factors for monolithic connections, it is important to properly evaluate the degree of fixity in the foundation. The following values can be used:

G_a

1.5 Footing anchored on Rock
3.0 Footing not anchored on Rock

5.0 Footing on Soil
1.0 Footing on Multiple Rows of End Bearing Piles

+
+
+
+



The following alternative K -factor equations [Duan, King and Chen 1993] may be used.

For braced frames

$$K = 1 - \frac{1}{5+9G_a} - \frac{1}{5+9G_b} - \frac{1}{10+G_a G_b} \quad (\text{C-3})$$

For unbraced frames
for $K < 2$

$$K = 4 - \frac{1}{1+0.2G_a} - \frac{1}{1+0.2G_b} - \frac{1}{1+0.01G_a G_b} \quad (\text{C-4})$$

for $K \geq 2$

$$K = \frac{2\pi a}{0.9 + \sqrt{0.81 + 4ab}} \quad (\text{C-5})$$

where:

$$a = \frac{G_a G_b}{G_a + G_b} + 3 \quad (\text{C-6})$$

$$b = \frac{36}{G_a + G_b} + 6 \quad (\text{C-7})$$

where G_a and G_b are defined by Eq. (C-2).

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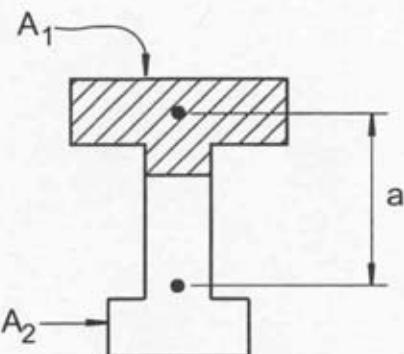
APPENDIX D

COMPUTATION OF PLASTIC SECTION MODULUS Z*

The plastic modulus Z is the statical first moment of one half-area of the cross section about an axis through the centroid of the other half area when a section is made of same steel material.

When a section is built up from plates or shapes of more than one yield strength, the plastic moment should be computed on the basis of equilibrium on the cross section with all fibers stressed to the appropriate yield strength in either tension or compression.

*Information in this Appendix is obtained from the Commentary of AISI Bulletin 15. Values of Z for rolled sections are listed in the Manual of Steel Construction, Eighth Edition, 1980, American Institute of Steel Construction.



$$A_1 \text{ (shaded)} = A_2 \text{ (clear)} = A/2$$

$$a = \text{distance between centroid of } A_1 \text{ and } A_2$$

$$Z = aA_1 = aA_2$$